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# **Health and Safety In-House and Contract Research and Development in Fiscal Year 1983**

**By Staff, Division of Health and Safety Technology**



**UNITED STATES DEPARTMENT OF THE INTERIOR**



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By Staff, Division of Health and Safety Technology



UNITED STATES DEPARTMENT OF THE INTERIOR

James G. Watt, Secretary

BUREAU OF MINES

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# HEALTH AND SAFETY IN-HOUSE AND CONTRACT RESEARCH AND DEVELOPMENT IN FISCAL YEAR 1983

By Staff, Division of Health and Safety Technology

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## ABSTRACT

This publication summarizes, for potential contractors and all other interested parties, the research and development of in-house and contract projects programmed by the Bureau of Mines for fiscal year 1983 (October 1, 1982-September 30, 1983) under its Health and Safety Technology program. The objective of these projects is to provide an ordered and sequenced series of advance toward the Bureau's overall goal of providing the systems technology required to create a more healthful and safer working environment for the Nation's mining and minerals processing workers.

## INTRODUCTION

The Bureau of Mines conducts a balanced, continuing in-house research and development program to accelerate systematic improvements in health and safety conditions in U.S. mines. Part I of this report outlines the Bureau's present in-house effort to all interested parties; in particular, potential contractors can refer to it when submitting USP's (unsolicited proposals), thus avoiding proposing research that duplicates work being performed by the Bureau.

It is the policy of the Bureau of Mines to utilize as fully as possible the capabilities of the private sector in minerals research, and to that end Part II of this report outlines the Bureau's current projected contract research needs.

The projects presented were planned at the beginning of the fiscal year and are subject to change based on emerging priorities and availability of funds. Contingencies may require that a significant portion of the program be deferred into fiscal year 1984 (FY 84) or beyond. It is important to realize that since this is a summary document, the project descriptions related to a design, fabrication, and demonstration effort do not necessarily imply total package procurement.

Contracts for the Health and Safety Research program will be conducted in strict accordance with Federal Procurement Regulations. Availability of requests for proposals (RFP's) will be formally advertised in the Commerce Business Daily. No additional information will be supplied on these projects until after the RFP's are made available and then only in strict accordance with prescribed procedures. This document is not intended to solicit proposals from the contracting community. All USP's whose content reflects the objective(s) of the proposed projects listed herein will be returned without formal review.

## PROGRAM OUTLINE

The objective of the Health and Safety Technology program is to protect the health and safety of mining and minerals processing workers while insuring that newly developed technology incorporates health and safety criteria. In achieving this objective, four fundamental and complementary requirements must be considered by the research program, as follows:

1. Contributing to the viability of a basic industry.
2. Sustaining productivity.
3. Allowing for a return on capital investment.
4. Providing material and energy to the public.

Since mining and minerals processing involve a highly integrated and interrelated set of functions, the program has been divided into a set of interrelated subprograms, each with goals that will provide systems technology solutions to the problems within the framework of these fundamental requirements.

The Health and Safety Technology program is divided into 12 subprogram areas as shown:

### Health

Respirable dust  
Radiation hazards  
Noise control  
Industrial hygiene  
Ventilation

### Safety

Fires and explosion prevention  
Methane control  
Ground control  
Industrial-type hazards  
Postdisaster  
Explosives  
Systems engineering

The objectives of these subprograms are described in the following pages, followed by the planned projects and their corresponding descriptions. The aggregate value of the planned in-house projects is approximately \$23 million and of the anticipated contracts, \$8 million.

## PART I.--IN-HOUSE RESEARCH

### Health

#### Respirable Dust

Program Objectives: To develop procedures for controlling the respirable dusts that still constitute the severest health problem facing the mining and mineral processing industries. To develop and/or improve techniques and equipment to prevent formation of hazardous dust concentrations, and to protect miners against dusty atmospheres.

### Control of Dust Formation

#### 1. Reduction of Airborne Coal Dust With Increased Machine Efficiency

Objective: To develop background information of a fundamental nature on coal cutting technology that supports long-term solution to problems of primary dust generation during coal cutting. Specifically, to continue research on the relationship between bit geometry and

dust generation; to continue to develop in situ cutting force and dust information data using the Bureau-developed "in-seam tester;" and to initiate multiple-bit testing on a full-diameter, one-quarter-wide continuous mining machine drum section to evaluate bit interaction and/or lacing effects on primary respirable dust generation.

#### Control of Generated Dust

##### 2. Dust Control by Chemicals and Chemical Additives

Objective: To continue development of wetting agent selection criteria and correlate with in-mine results. To investigate methods, such as the addition of small quantities of dispositive ions, for making wetting agents more effective on coal at low concentrations. To establish which mining operations can benefit from the use of surfactants. To continue laboratory studies to determine the effectiveness of calcium chloride and wetting agents on airborne dust reduction.

##### 3. Development of Improved Dust Control Technologies for Coal Mines

Objective: To continue to develop and evaluate improved dust control techniques in underground coal mines based on the use of remote control, double brattice ventilation, high-pressure conventional sprays, and water-powered scrubbers. To conduct surveys on mining faces to determine dust sources and the effectiveness of control techniques. To develop improved techniques to evaluate longwall face ventilation. To continue to develop improved dust sampling strategies for the evaluation of longwall dust control technology. To continue to transfer technology developed under contracts and in-house studies to the mining industry.

##### 4. Dust Control Technologies for Metal and Nonmetal Mines and Processing Mills

Objective: To continue to conduct preliminary studies leading to development of improved dust control techniques for metal and nonmetal mines and mineral processing mills. To evaluate various preconditioning agents and their effect on lowering overall dust levels in processing plants. To determine whether the sampling efficiency of the 10-mm Dorr-Oliver cyclone is adversely impacted by high air velocities and orientation relative to the airflow.

##### 5. Analysis of MSHA Health and Safety Inspection Data From Metal and Nonmetal Mines

Objective: To develop a health hazard index for metal and nonmetal mines that will aid the Mine Safety and Health Administration (MSHA) in determining its inspection and sampling strategy, and in ranking mine health hazards. To maintain and expand the Mine Inspection Data Analysis System (MIDAS) to include information from the Bureau's Minerals Availability System (MAS) data base.

#### Dust Instrumentation and Measurement

##### 6. Respirable Dust Measurement and Instrumentation Evaluation

Objective: To continue the design of coal mine respirable dust monitoring strategies for control of the miner's exposure. To conduct evaluations of newly developed instruments and measurement techniques. To seek out new aerosol detection techniques and determine feasibility of applying them to the measurement needs of the mining industry. To maintain an aerosol laboratory and continue to improve the in-house expertise in aerosol measurement.

7. Determination of Silica Particle Size Distribution in Respirable Mine Dust Samples

Objective: To provide reliable silica determinations for effective enforcement and control of dust levels in mines. Specifically, silica particle-size distributions will be determined on mine respirable dust samples to allow selection of a matched distribution in the silica standard material used for silica analysis.

Radiation Hazards

Program Objectives: To develop and provide new and improved measurement instrumentation and control technology for protection of miners from exposure to radon and radon daughters and other nuclear radiation hazards in uranium and other mines.

Control of Radiation Hazards

1. Radon Control Technology

Objective: To continue to evaluate the effectiveness of overpressurization ventilation on radon control for typical thicknesses, grades, and physical properties of ore, subore, and waste using computer simulation. To continue modeling of diurnal barometric pressure change and its effects of radon entering the environment, and to examine the potential of incorporating fractures and moisture effects in the porous media models. To conduct preliminary surveys in at least two active mines to determine the extent of radon transported by mine water and develop corrective measures. To evaluate the effectiveness of bulkheads to control radon emanation from a nonproductive area in one mine.

2. Control of Radon Daughters Through Air Cleaning and Other Removal Techniques

Objective: To continue studies on various methods of removing radioactive components from mine atmospheres.

Emphasis will be on determining the feasibility of using methods other than filter media for removing radioactive particulates, such as water sprays, negative ion generators, and special membranes. To provide necessary technical assistance to the contractor during testing phase of a prototype air-cleaning system.

Radiation Instrumentation and Measurement

3. Personal Exposure Instrumentation and Measurement Technology

Objective: To continue studies on passive radon dosimeters that will include (1) overall accuracy in a mine environment, (2) improvement in sensitivity through electrostatic collection, and (3) determination of the characteristics of the equilibrium factor (F) needed to convert cumulative radon measurements to cumulative radon daughter measurements. To continue evaluation of airless continuous working level detectors through both laboratory and active mine studies. To continue evaluation of beta detectors for rapid working level measurements by grab sampling techniques that do not use air collection on filters. To evaluate commercial radon daughter measuring systems for accuracy and reliability in mine environments. To determine the validity of radon sampling for measuring concentrations of radon and radon daughters.

4. Radiation Warning System for Uranium Mines

Objective: To determine the feasibility and benefits of combining the desirable features of the 32-channel and the 500-channel systems into one system. This system will have the capability to sound alarms both at the surface and underground, record conditions, turn fans on and off, and as monitor power use, ventilation, and other critical engineering parameters and environmental conditions. The system also will have the capability of printing out trend logs (historical) and shift reports (averaged readings per shift) for up to 30 detectors or monitors. Field evaluation of

the improved system will be conducted in two active mines.

### Noise Control

Program Objectives: To work with industry to identify noise sources in underground and surface mines and in related mineral cleaning and preparation facilities, and to abate these noise sources sufficiently to meet Federal noise exposure standards.

#### 1. Development of Noise Control Techniques for Coal Mining Machinery

Objective: To further the implementation of noise control techniques by the mining industry. This will be accomplished via equipment development and dissemination of information.

#### 2. Noise Control Research and Testing of Mining Machinery

Objective: To extend the capability to acoustically evaluate the performance of mining machinery in order to make comparisons of equipment performance before and after noise control technology has been applied. To test long-term reliability of mining equipment to which noise control technology has been applied.

#### 3. Reduced Gear Noise Research

Objective: To initiate a literature search and analysis of noise control of gear sets and transmissions in order to assess the applicability to mining machinery.

#### 4. Measurement of Noise Reduction Provided by Hearing Protectors Worn by Miners

Objective: To investigate methods of evaluating hearing protector performance that could be used to determine the degree of noise reduction provided in the field. The in-mine performance of personal hearing protectors is to be established, along with procedures and

equipment to make in-mine measurements of hearing protector performance.

### Industrial Hygiene (Toxic Substances)

Program Objectives: To identify and control health hazards in surface and underground mines and mineral processing plants caused by toxic gases and fumes, and certain particulates produced by explosives, combustible materials, and diesel engines. To develop and evaluate new instrumentation for monitoring these substances. To develop and/or refine analytical techniques for measuring and characterizing toxic substances, and investigate methods for controlling the formation and accumulation of toxic products. To analyze alternative power sources that may have health advantages over existing mine diesels.

### Toxic Gases and Materials

#### 1. Explosive Fume Characterization

Objective: To establish the relationship between toxic fumes produced in a 38,000-L chamber and those produced in the Bichel Gage and C-J apparatus and relate these to actual explosive fumes from in-mine measurements. To carry out fume measurements on all types of mining explosives including blasting agents and establish standard test procedures for the measurement of toxic fumes.

#### 2. Improved Instruments for Mine Gases

Objective: To evaluate and verify the performance of commercially available or contract-developed instruments and devices for noxious and toxic gases. To acquire instruments and devices and evaluate their operation under varying conditions of temperature, humidity, and pressure. To determine the stability, accuracy, precision, sensitivity, and applicability to measure noxious and toxic gases in the mining environment. To assess air quality monitoring strategies and methods to determine their effectiveness in the underground mine environment. To develop a portable, self-contained

self-contained diesel exhaust gas analyzer which is mine rugged.

### 3. Measurement and Control of Welding Fumes

Objective: To assess related industry practices pertaining to measurement and control of welding and cutting fumes, dust, and radiation, and adapt this technology to confined work areas found in the mining environment. To determine the quantity and character of welding pollutants and personnel exposure levels. To propose control systems and/or isolation techniques to reduce or eliminate exposure to toxic substances resulting from welding and cutting.

### 4. Mercury Vapor Suppression in Mercury Ore Processing

Objective: To determine the conditions under which mercury vapor is released during grinding and froth flotation operations, and correlate these conditions with measured levels of vapor emissions. To develop a hydrometallurgical alternative to the present roasting process for processing mercury concentrates into the pure metal.

### Diesel Engines and Alternative Power Sources

### 5. Control of Diesel Exhaust Contaminants

Objective: To supplement contract research in the control and analysis of diesel exhaust emissions. To measure ambient contaminants and correlate with emissions data. To investigate control systems for contaminants by means of laboratory experiments. To devise and select analytical procedures for emission control systems and components at the tailpipe and ambient levels.

### 6. Investigation of Emission Controls for Diesel Engines Operated Underground and Alternative Power Source Assessment

Objective: To identify potential methods and hardware applicable for use as emission controls for turbocharged mine diesels. To review the literature as to the current state of knowledge pertaining to the use of internal combustion engines operating underground. To study applications of diesel equipment in new mining systems such as oil shale. To assess alternative power sources that may have health and operational advantages over existing mine diesels.

### 7. Industrial Hygiene Hazards

Objective: To analyze occupational and industrial exposure profiles for welding fumes and toxic gases and relate these to occupational illnesses reported to the Health and Safety Analysis Center (HSAC) and to analyze HSAC data in order to identify those areas where industrial hygiene problems are most severe.

#### Ventilation

Program Objectives: To develop ventilation systems required to maintain a safe and healthful atmosphere conducive to efficient work output in noncoal mines.

### 1. Development of Improved Ventilation Technology for Noncoal Mines and Mills

Objective: To develop improved technologies for ventilating and cooling stopes and development headings in hot metal and nonmetal mines. To develop improved and safe methods of heating shafts in winter to prevent ice buildups and to

make the transport of personnel comfortable. To continue to develop methods of ventilating dead-ended working headings in metal and nonmetal mines.

### Safety

#### Fire and Explosion Prevention

Program Objectives: To reduce the potential for a fire or explosion in mineral extraction and processing operations, to minimize the danger to people on account of fires or explosions that do occur, and to diminish the vulnerability to such attendant hazards as high temperature, asphyxiating and toxic fumes, and explosive gas mixtures.

#### Prevention and Detection Research

##### 1. Field Testing of Coal Mine Dust Incombustible Meter

Objective: To produce a suitable number (five) of field-prototype coal mine dust incombustible content meters for field testing.

##### 2. Remote Methane and Mine Fire Detection

Objective: To determine the Raman scattering properties of methane and other flammable gases, and demonstrate on a laboratory scale remote measurement techniques for these gases. To improve upon fire sensors and fire sensing methodologies, and determine detection criteria and associated guidelines for the optimum deployment of sensors and/or sensing systems for early warning of fires.

##### 3. Float Dust Formation, Deposition, and Control

Objective: To perform field tests on the effectiveness of techniques such as water sprays to control the amount of float coal dust. To field-test the IRAD dust deposition meter, which consists of a set of small sensor heads that can be

placed along an airway and wired to a remote readout meter.

##### 4. Mechanism of Dust Explosion Suppression

Objective: To determine the chemical and physical processes that underlie the flammability behavior of dusts and the effectiveness of powdered extinguishants in suppressing dust explosions.

##### 5. Ignition Hazard of Sintered Metal Brake Linings

Objective: To determine the extent of methane ignition hazard when using sintered metallic friction components in the braking systems of underground coal mining equipment. If a hazard exists, to develop an evaluation method that includes suggested guidelines.

##### 6. Mine (Fire) Ventilation Code, Modification and Maintenance

Objective: To improve the applicability, utility, and acceptability of the mine (fire) ventilation simulation computer program developed by Michigan Technological University (under contract J0285002) for the Bureau.

##### 7. Fire and Explosion Hazards of Large Diesel-Powered Mining Equipment

Objective: To delineate problems associated with the use of large mining equipment in gassy underground mines, to identify methods to make this equipment permissible for underground use, and to establish an in-house test capability to validate control technology.

##### 8. A Pneumatic Fire Detection System for Deep, Multilevel Shafts

Objective: To evaluate and field-test a rapid, reliable fire detection system for underground mines with deep, multilevel shafts.

## Ignition Research

### 9. Flammability and Spontaneous Combustion of Mine Combustibles

Objective: To improve and simplify the Bureau's conveyor belt flammability apparatus, evaluate the flammability hazard of aerosol electrical spray cleaners, develop a small-scale flammability test for ventilation dust materials, and investigate flame propagation of mine combustibles in a slope utilizing a tilting tunnel. To investigate the spontaneous combustion of coal, oil shale, and pyrites, develop reliable criteria for identifying self-heating hazards, and develop mathematical models of the spontaneous combustion process in piles of coal, oil shales, and sulfide ores.

### 10. Thermal and Electrical Ignition of Mineral Dusts

Objective: To delineate the domains of thermal and electrical ignitability of coal, oil shale, and other flammable mineral dusts. To determine the mechanisms of ignition, and to use these data to assess the hazards of surface facilities or other industrial operations that use or generate flammable dusts.

### 11. Improved Bit Materials for Continuous Coal Mining Machines

Objective: To reduce frictional ignitions by improving the materials or the configuration of materials used in coal cutter bits on continuous mining machines. In particular, to verify the optimal fraction of nickel in the cobalt-nickel binder, used for the tungsten carbide inserts, that will minimize frictional ignition.

### 12. Pacification of Sulfide Oxidation

Objective: To determine the kinetics and mechanisms of low-temperature oxidation of sulfides, particularly pyrite, to identify the rate-controlling step(s). To apply the result of this study to

identify chemical and physical inhibitors and validate, first in larger scale laboratory tests and ultimately in mines, the ability of these inhibitors to prevent or retard sulfide oxidation and thereby reduce the probability of mine fires and the resultant loss of property and life.

## Suppression Research

### 13. Laboratory Dust Flammability Testing

Objective: To develop a reliable standard apparatus and procedure for evaluating the flammability limit ignition sensitivity and pressure development for dusts, gases, vapors, and their mixtures. To test dust samples that are submitted from industry or other Government agencies, to correlate the data with full-scale studies in mines or large surface facilities, to investigate new inhibitors as alternatives or supplements to rock dusting, to determine hazard classifications for oil shale dusts, and to unify the diverse observations of flammability behavior into a coherent theory.

### 14. Microscopic Structure and Composition of Combustible Dusts and Residues

Objective: To conduct quantitative microscopic structure studies, size distributions, and composition analyses of various dusts with the scanning electron microscope, and to apply the data obtained to combustion research and the forensic science of postdisaster investigation.

### 15. Coal Mine Fire Protection System Component Ruggedization

Objective: To expand and improve the fire sensing system installed in the Peabody No. 10 underground coal mine under Bureau of Mines--Engineering Systems Development Contract H0100017 by development of permissible or intrinsically safe components and inclusion of fire sensing

capability in the south shaft. To assist commercialization of vehicle fire protection systems previously developed under this project.

#### 16. Improved Mine Fire Protection

Objective: To improve fire safety in underground metal and nonmetal mines through tests of improved early fire sensing and/or warning systems at FMC's Green River trona mine, Noranda's Lake-shore copper mine, Bunker Hill's silver mine, International Salt's Detroit salt mine, and AMAX's Henderson molybdenum mine.

#### Propagation and Extinguishment Research

#### 17. Full-Scale Mine Explosions

Objective: To conduct research on the propagation and suppression of full-scale explosions of dust and gas in experimental mines, to test explosion-proof bulkheads, and to develop and maintain instrumentation in both the Bureau's experimental mine and the Lake Lynn Laboratory.

#### 18. Mine Fire Diagnostics

Objective: To continue developing needed guidelines for safe reopening of a mine following sealing of a coal mine fire, to evaluate mine fire detection and suppression systems, and to evaluate full-scale fires involving other mine combustibles such as mine dusts, brattice curtains, and conveyor belts.

#### 19. Prevention and Suppression of Ignitions and Explosions

Objective: To develop, test, and conduct field trials of (1) new tool bit materials and/or tool bit geometries for the prevention of face ignitions, (2) barriers for the suppression of face

ignitions, and (3) of gas and coal dust explosion barriers.

#### 20. Fire and Explosion Hazards of Oil Shale and Oil Mining

Objective: To continue to test fire and explosion hazard scenarios in large-scale tests involving bulk material and dust, to monitor methane emissions in operating oil shale mines and vapor and/or mist hazards in oil mines, and to conduct laboratory evaluations of spontaneous combustion of oil shale and explosibility of retort gas and oil vapor.

#### Methane Control

Program Objectives: To develop, demonstrate, and transfer (1) technology that will prevent the formation of flammable methane-air mixtures in underground mine workings through improved ventilation and (2) procedures for degasifying the mineral deposit in advance of and during mining. To establish correlations between the geology of the mineral, adjacent strata, and their gas content, and to use these correlations to predict methane emission hazards.

#### Fundamental Factors

##### 1. Prediction of Coalbed Discontinuities To Increase Effectiveness of Drilling for Methane Drainage

Objective: To determine fundamental geological criteria that can be used to predict the presence of coalbed discontinuities in advance of mining and to refine statistical techniques that can be used to evaluate the probability of encountering discontinuities during methane drainage drilling. Particular emphasis will be placed upon those discontinuity characteristics that adversely affect methane drainage projects.

2. Influence of Geology on Occurrence and Emission of Methane in Coal Measures

Objective: To conduct geologic investigations of gassy, minable coalbeds to determine the factors controlling the amount and distribution of methane and the effect on mining, to determine the gas contents of U.S. coalbeds and improve predictive techniques, to determine the influence of coal macerals on gas generation and retention, and to aid in assessing the geologic feasibility of proposed methane drainage sites.

3. The Origin and Geologic Influences on the Migration of Methane Into Metal and Nonmetal Mines

Objective: To establish, by means of data obtained by in-mine and laboratory studies, the stratigraphy and geological structures that contribute to varying concentrations of gases within metal and nonmetal mines, to determine the composition of gases and the factors that influence the migration and retention of these gases into metal and nonmetal mines, and to develop predictive models for the occurrence of gassy areas within the ore bodies in advance of mining.

Control in Advance of Mining

4. Application of Vertical Borehole Methane Drainage to Mine Safety

Objective: By demonstrating the feasibility of draining gas in advance of mining from gassy coalbeds through vertical boreholes, to determine the effects of borehole spacing and methods of stimulation on reducing methane gas emissions into mine workings.

Control During Mining

5. Application of Horizontal Drilling Technology to Health and Safety Problems in Metal and Nonmetal Mines

Objective: To conduct detailed analyses of methods for locating and

identifying gas-bearing zones in metal and nonmetal mines by drilling small-diameter holes in advance of mining, and to investigate techniques for reducing or eliminating the hazards associated with the rapid release of energy (outbursts) when mining encounters the gas-bearing zones.

6. Development of Control Techniques Using Horizontal Boreholes

Objective: To determine the effectiveness of long, horizontal boreholes in reducing methane levels during mining through natural drainage, and to determine the application of drilling in advance of mining to locate and identify areas such as clay veins, fault zones, and other coalbed discontinuities that may cause problems for future mining.

7. Gob Degasification From Underground Locations

Objective: To develop a method for controlling methane in gob areas of retreating longwall panels by drilling small-diameter boreholes into the overlying strata from underground locations. Optimum spacing, length, and angle of holes above horizontal must be determined to extract the maximum quantity and purity of methane from the gob and to prevent it from entering the ventilation system of the mine. Optimum design parameters for the gob drainage system will be developed for geologic conditions above the Upper Kittanning Coalbed and within 2 years for geologic conditions above the Pittsburgh Coalbed.

8. Design of Horizontal Drilling Equipment for Increasing the Cost Effectiveness of Methane Drainage

Objective: To design, develop, and improve horizontal drilling equipment and pipeline equipment for use underground that will improve methane drainage technology and make it more reliable and cost-effective.

## 9. Ventilation in Control of Methane

Objective: To develop improved ventilation methods for methane dilution in gassy coal, metal, and nonmetal mines. This includes techniques for increasing airflow as well as improved methods of assessing the degree of hazard that exists.

## 10. Development of Improved Horizontal Hole Grouting Techniques

Objective: To improve presently available techniques of grouting horizontal methane drainage holes.

## 11. Assessment of the Potential for Gas Outburst Hazards in Coal Mines

Objective: To generate criteria for evaluating and determining the potential for gas outbursts in coal mines.

### Ground Control

Program Objectives: To conceive, develop, demonstrate, and transfer technology that will prevent mine accidents attributable to falls of ground, outbursts, slope failures, and collapse of waste impoundment structures.

### Mine Design and Development

#### 1. Delineation of Abandoned Mine Workings and Other Mining Hazards With Integrated Geophysics

Objective: To field-test high-resolution seismics, acoustic seismics, radar, resistivity measurement, and controlled-source tellurics over known abandoned mine workings. The data from these tests will be processed with the latest integrated geophysics modeling, and reverified with onsite drilling.

#### 2. Computerized Remote Sensing Techniques for Detection of Potential Hazards in Mine Areas

Objective: To refine and demonstrate to the mining industry the use and the advantages of a computerized

lineament mapping technique for detecting geologic hazards, which may cause sudden inundation and roof falls. Also to evaluate the correlation between linear features and mine hazards by comparing selected regional geophysical data and lineament information.

#### 3. Develop Improved Coal Mine Design Procedures

Objective: To improve the MIN SIM (mine simulation) computer program for application to coal mine design, and demonstrate its use in designing safer coal mine openings, pillars, and extraction layouts.

#### 4. Evaluation of Room-and-Pillar Design Methods

Objective: To validate theoretical and empirical pillar design methods with in-mine instrumentation, and prepare updated design guidelines for room-and-pillar coal mines.

#### 5. Entry Design for Longwall Mining on Steeply Pitching Coal Seams

Objective: To demonstrate the application of computer modeling techniques to planning of an advancing longwall mining system in a steeply pitching coal seam, with emphasis on establishing an optimum safe entry width as a function of overburden depth, evaluating a new concrete crib design, and determining acceptable packwall requirements.

#### 6. Face Slabbing Along High Longwall Faces in the Western United States

Objective: To investigate the face slabbing problem along high longwall faces in the Western United States and devise remedial measures for controlling face slabbing in order to improve mine safety.

#### 7. Longwall Mining Design Parameters

Objective: To determine the critical design parameters for safe longwall mining systems by measuring pillar constraints, mining-induced load transfer,

roof and floor strata movements, and face support loads.

8. Design of Single Entries for the Safe and Efficient Development of Steep Seam Longwall Panels

Objective: To design a single-entry, retreat longwall mining system that may be applied to steep-seam coal mining for improving mine safety and productivity.

9. Evaluate Borehole Instruments for Rock Mechanics Investigations

Objective: To evaluate the performance and long-term stability of various types of borehole instruments available for rock mechanics study under biaxial loading conditions, and investigate the effects of time and temperature on their performance.

10. Inexpensive Testing Techniques Used in Mines on Unprepared Rock and Coal Samples

Objective: To evaluate available in-mine testing methods for determining physical properties of coal and rocks from unprepared samples, and develop recommended practices.

11. Design of Mine Plans for Longwall Mining of Multiple-Seam Coal Reserves

Objective: To apply the numerical model analysis of mine structures to design of multiple-seam longwall mining systems with emphasis on determining the optimum mining sequence and the overburden load transfer characteristics.

12. Development of Classification of Mine Roof According to Support Mechanism Efficiency

Objective: To develop a systematic framework for classifying mine roofs based on the effective roof control techniques being used in mines and compile roof support selection guidelines.

13. Anchorage of Inundation Bulkheads in Coal Mine Openings

Objective: To test and evaluate various methods of anchoring inundation bulkheads in underground coal mine openings and develop technical guidelines for inundation bulkhead design and construction.

14. Development of Design Procedure To Be Used in Layout of Workings in Multiple-Seam Mining Situations

Objective: To develop a technique to assess the impacts of a mine layout in the vicinity of a previously mined seam, based on the case study of an active coal mine that is engaged in multiple-seam mining.

15. Prediction of Unstable Mine Roof Based on Remote Sensing Analysis

Objective: To verify the relationship between photolinears and unstable roofs and identify the hazardous geologic features associated with the photolinears in selected coal mines.

16. Pressure Grouting To Control Water Seepage Through Barrier Pillars and Strata Surrounding Inundation Bulkheads

Objective: To evaluate pressure grouting techniques as a means to control water seepage through barrier pillars and the roof, rib, and floor strata surrounding an inundation bulkhead. Field tests of selected grouting methods and their effectiveness will be conducted.

17. Ground Control Measures for Coal Mines Operating Under Mined-Out Areas

Objective: To conduct a survey of past, current, and proposed ground control measures for coal mines that are operating beneath previously mined-out areas, and establish a data base for ground control planning.

18. Effectiveness of Air-Tempering Entries in Reducing Shale Roof Disintegration

Objective: To determine the long-term effectiveness of air-tempering entries in reducing shale roof disintegration at the Valley Camp No. 1 Mine, W. Va., in order to confirm the benefits of the humidity control technique.

19. Effects of Excessive Roof Loading on Mine Supports, Installations, and Openings

Objective: To observe physical signs of excessive roof loading on various types of mine supports and mine structures, and compile an illustrated guide for identification of roof hazards.

20. Hazardous Roof Structures and Special Support Techniques

Objective: To conduct a survey hazardous geologic structures and associated coal mine roof conditions in the northern Appalachian coal region, and identify the support techniques best suitable for each particular roof condition.

21. Model Studies and Field Verification of Roof Bolting Criteria

Objective: To develop design guidelines for mine roof reinforcement using mechanically anchored bolts, fully-grouted resin bolts, friction stabilizers, inorganic-cement-grouted bolts, inclined bolts, and roof truss systems. This work will be accomplished by collating the results of full-scale model testing, finite-element computer analysis, and in-mine tests.

22. Single-Entry Development Systems for Longwall Mining

Objective: To develop alternative designs of single-entry development system for retreat longwall mining, complete synthesis of previous experimental data, and determine recommended variances in health and safety requirements that will

permit employing single-entry longwall mining concepts in the United States.

23. Roof Stability Through Automated In-Mine Environmental Control

Objective: To measure surface properties of coal mine roof rocks and determine swelling pressure and strain in rocks under dry and wet conditions in order to establish a technical basis for mine humidity control to achieve maximum roof stability.

24. Blasting Parameters That Affect Highwall Stability

Objective: To determine by field tests the effect of controllable blasting parameters on overbreak, and to develop a design guide for improved highwall stability in surface coal mining.

25. Engineering Recommendations for Geotechnical Investigations of Hazardous Ground

Objective: To conduct a survey of geotechnical investigation practices in mining, tunneling, and civil engineering industries, and to identify the best practices for use in coal mines to prevent accidents due to unexpected ground failures.

26. Analyses of Rock Fall and Geologic Hazard Data

Objective: To search, retrieve, and analyze rock fall case histories, accident reports and statistics, and ground control plans of underground coal mines to obtain an in-depth perspective on the conditions contributing to roof falls and roof fall accidents, evaluate the effectiveness of mine support, and identify future research needs.

27. Application of Geodynamic Accumulated Strain Sensor To In Situ Rock Stress Measurement

Objective: To develop acoustic transducers for in situ rock stress

measurement based on the pulsed-phase-locked-loop technology that has been developed by a cooperative effort between the Bureau and the National Aeronautics and Space Administration. Field application of the geodynamic accumulated strain sensor will be demonstrated.

**28. Evaluation of Ground Stability Problems in Quarry Operations**

Objective: To investigate ground movements and highwall stability at a co-operating slate quarry in eastern Pennsylvania, and identify ground control problems associated with such quarry operations. Application of geotechnical engineering to quarry planning and operations will be demonstrated.

**29. Mine Planning To Reduce Ground Control Problems and Rock Burst Hazards in Deep Vein Mines**

Objective: To perform a structural analysis of mine models of a variety of cut-and-fill mining methods for vein-type mineral deposits at great depths, using various combinations of mining systems, destressing techniques, stope geometries, excavation sequences, and fill materials for the purpose of reducing safety hazards inherent to deep vein mines. The use of flexible liners to prevent damage to raises, when rock preconditioning by blasting is used for rock burst control in the stope, will be investigated also.

Hazard Detection and Monitoring Systems

**30. Automated Roof Fall Warning System**

Objective: To evaluate the performance of the prototype microseismic roof fall warning system at a variety of mine sites and transfer the innovated technology to the industry.

**31. Coal Mine Bounce and Outburst Studies**

Objective: To identify seismicity patterns prior to coal mine bounces and outbursts using the digital microseismic monitoring and recording system developed

by the Bureau, and demonstrate utilization of microseismic techniques for prediction and early warning of coal bounces and coal and gas outbursts at selected deep coal mines.

**32. Mine Roof Movement Warning System**

Objective: To evaluate the prototype roof movement monitoring and warning system using a laser beam by a series of in-mine tests, and transfer the innovated technology to the industry.

**33. Application of In-Seam Seismic Techniques for Detection of Voids and Faults**

Objective: To establish the uses and limitations of seismic seam wave technology for detecting mine voids and faults ahead of the working face in U.S. coal mines. Emphasis will be placed on field acquisition of guided wave data under known geologic conditions, and on the determination of optimum field operation techniques and seismic source-detector configurations.

**34. Cleat Influence on Pillar Bursts in Coal**

Objective: To investigate the relationship between coal cleat characteristics and coal bump potential, and develop a practical method that will enable miners to identify potential hazards by a quick inspection of coal seams.

**35. Mine Inundation Warning Systems**

Objective: To investigate methods and equipment capable of providing a warning in the event of mine inundation. The best suitable instrumentation will be tested in mines to evaluate its effectiveness.

**36. Deconvolution as a Technique for Performance Improvement of the Synthetic Pulse Radar Method**

Objective: To develop signal enhancement techniques for the synthetic pulse radar being developed under a

Bureau contract for coal mine hazard detection, using a deconvolution method based on computer analyses of physical models. The theoretical studies will be validated by a laboratory experiment using liquid-filled coaxial waveguide sections to simulate subsurface media.

37. Develop and Demonstrate Ultrasonic Closure Rate and Roof Fall Prediction Device

Objective: To field-test an intrinsically safe ultrasonic roof-to-floor closure rate measuring device which is nonobstructing for use in haulageways and other high-traffic areas for early prediction of roof falls. The test results will be compared with those of an electronic closure rate measuring device using potentiometric extensometers.

38. In-Mine Hazard and Bad Roof Detection Systems

Objective: To fabricate a cross-roof acoustic system and an impact hammer-accelerometer system, which have been designed by the Bureau, for detecting hazardous roof conditions in coal mines. Their performance will be evaluated by laboratory and field tests.

39. Prediction and Control of Rock Bursts and Failures in Mines

Objective: To conduct coordinated research in the application of microseismic techniques to prediction of catastrophic ground failures in deep vein mines. The tasks include continuous monitoring of microseismic activity from burst-prone stopes using a digital microseismic monitoring and recording system, analysis of the field data to determine seismicity patterns prior to a rock burst, verification of the reliability of rock burst prediction and warning, evaluation of a portable rock burst monitor and ultrasonic sensors as a supplement to the main microseismic rock burst monitoring system, and a feasibility study of developing a laser-based microseismic transducer.

40. Develop Fiber Optic Transmission System for Seismic Events

Objective: To improve the transmission of seismic data from a rock burst monitoring system in electrically noisy mediums by eliminating all electrical connections between the transducer and the recording instrument and replacing it with fiber optic transmission. Fiber optic links will be designed and installed for a microseismic geophone network for field evaluation.

41. Detection of Rock Fall Hazards Utilizing Electromagnetic Sensors

Objective: To evaluate the performance of a prototype ground penetrating radar which has been designed and constructed by the Bureau for detecting roof and rock fall hazards in mines. The prototype unit will be tested in selected underground metal, nonmetal, and coal mines. If the test results prove successful, an attempt will be made to repackage the ground penetrating radar into a simplified portable and permissible unit.

Roof Support Systems

42. Inorganic Grout for Coal Mine Roofs

Objective: To develop practical systems for installing fully grouted coal mine roof bolts with fast-set inorganic cements. Material properties for the inorganic full-column roof bolt systems will be determined, and field tests will be conducted on the water microcapsule and gypsum cement cartridges in selected mines.

43. Effectiveness of Angle Bolting To Support Cutter-Type Roof

Objective: To provide the mining industry with an effective method of supporting cutter-type (shear or snap top) roof using angle bolting.

44. Inorganic Grout--Material Study

Objective: To provide a fundamental analysis of hydrocal plaster, quantify chemical and mechanical properties of Hydrocal-water capsule reaction products, and examine the special qualities and problems of the Hydrocal-water capsule system for grouting roof bolts.

45. Field Evaluation of Existing and Innovative Roof Bolt Elements

Objective: To complete documentation of comparative bolt properties for innovative roof bolts so that these bolting systems can be evaluated by comparison to standard parameters previously established. Secondly, determine in situ performance of novel bolting systems through in-mine testing.

46. Effects of Bolt Installation Procedures on Mine Roof Stability

Objective: To determine required resin-column length for insuring integrity of resin-grouted bolts, evaluate the Energy and Minerals Research Co. ultrasonic stress device for testing resin-grouted bolts, and complete the evaluation of the effects of installation procedures on resin-grouted bolts.

47. Mine Roof Stabilization Using Inorganic Chemical Bonding

Objective: To develop chemical binders and methods of application to mine roofs to increase the mine roof stability, with special attention to potential inorganic binders.

48. Inorganic Grouted Rock Bolts

Objective: To develop an inorganic grout system suitable for the large bolt holes commonly drilled in metal and non-metal mines. The initial task will be to identify reasons for poor anchorage of small-diameter bolts grouted in large-diameter holes. Pull tests will be made

with different size rebar grouted in holes drilled in concrete blocks with a 1-3/8-inch drill (commonly used in metal and nonmetal mines).

49. Evaluation of Plates on Resin-Grouted Roof Bolts

Objective: To perform field tests to determine the effectiveness of plates used with resin-grouted bolts.

50. Modular Concrete Post Design and Development

Objective: Utilizing the basic technology developed in the steel fiber reinforced concrete crib program, to develop sectionalized concrete posts for mine roof support.

51. The Investigation and Development of Face Protection Systems To Control Existing Hazardous Roof Conditions on Longwalls

Objective: To develop and evaluate techniques to minimize the hazards created by the fall of friable roof at longwall faces.

52. Anchorage Problems With Resin-Grouted Roof Bolts

Objective: To perform laboratory investigations on the problems of glove fingering and insufficient grout with fully grouted roof bolts.

53. Yielding Mine Roof Supports

Objective: To develop a high-strength cylindrical roof support that yields in a controlled manner.

54. Concrete Crib Field Test

Objective: To complete final testing and report on the project. The report will contain results of laboratory and field tests and discuss commercialization of the cribs.

55. Sealants To Stop Shale Degradation--  
Long-Term Evaluation

Objective: In cooperation with a mine operator, to monitor the long-term weathering ability of several shale sealants.

56. Evaluation of Roof Trusses

Objective: To test a device developed under a Bureau contract for determining the tension in horizontal truss rods.

57. Support Systems for High  
Underground Openings in  
Thick Coalbeds

Objective: To investigate various support systems for high development openings in underground coal mines.

58. Analysis of Various Tunnel  
Linear Shapes

Objective: To develop engineering data to determine most effective and efficient tunnel liner shapes for use in resupport work where roof falls have occurred.

59. Minimum Column Lengths for  
Resin-Grouted Bolts in  
Evaporites

Objective: To determine the minimum column lengths required to ensure safe working conditions when rock conditions are such that some grout is forced out into the rock mass.

Safe Support Installation

60. Determination of Decay in Mine  
Timber

Objective: To test the timber decay system developed under contract H0202009 to evaluate the effectiveness of the

instrument to determine the strength loss of rotted timber.

61. Control-Prevention of Ignitions  
From Light Metals Impact

Objective: To determine the feasibility of alloy modification and/or protective coatings on mining equipment made of aluminum alloys to prevent or retard ignition potential. To determine the causes of ignition-inducing reaction arising from the rubbing impact of light metals and steels.

62. Field Test and Modification of  
Lightweight Hydraulic Props

Objective: To complete long-term field testing of lightweight props and modify them, if necessary, to improve the safety of handling and support functions in various seam heights and mining conditions.

63. Preparation of Longwall Support  
Selection Guide

Objective: To prepare for the mining industry a guide for selecting the optimum longwall support system for a particular set of mining conditions.

64. Retreat Mining Methods--Field Study

Objective: To identify changing ground conditions during various retreat mining operations and provide guidelines for uniform safety practices during retreat mining by FY 85. Instrumentation will be installed at two sites during development and retreat mining to monitor stress patterns and convergence during the various mining sequences. Observations and mine inquiries will be made along with instrument monitoring at the test sites to gain a better understanding of the ground conditions, method of operation, and hazards associated with retreat pillar operations.

65. Backfill Material for Tunnel Liners

Objective: To test and write specifications and recommendations for the use of backfill material (in conjunction with specific liner geometry) that is used to insulate tunnel liners from the impact loading of roof falls through the absorption of energy and redistribution of loads.

66. Metallurgy Evaluations

Objective: In coordination with MSHA Technical Support, to establish and maintain a program at the Bureau's Rolla Research Center for metallurgical evaluation of roof-rock bolts and other steel supports.

67. Corrosion of Metallic Roof Support Elements

Objective: To develop guidelines to aid MSHA and mining personnel in predicting the life of roof support systems, determine detrimental effects of corrosive mine environments on friction rock stabilizers (split set), and help identify potential control measures.

68. Improved Roof Sounding Techniques

Objective: To develop a piece of hardware that can be easily used to determine the competency of roof rock in mines. This device may be either incorporated in a scaling bar or a stand-alone device.

69. Scaling Technology

Objective: To develop a safer, more effective, and less strenuous means of scaling mine roof and ribs by testing, analyzing, and modifying, if necessary, scaling tools developed from previous contracts.

70. Investigation of Longwall Gateroad Roof Support Characteristics

Objective: To complete the development of rational design criteria and support system techniques for longwall

gateroad entries, based on underground tests and data collection.

71. Ground Control Accident Data Evaluation and Analysis

Objective: To examine ground control accident reports to determine trends and significance of conditions and circumstances contributing to accidents and fatalities.

72. Equipment Evaluation

Objective: To develop in-house capability for evaluation and modification of ground control equipment, monitor ongoing ground control equipment performance and tests.

73. Support of Thick Coal Roof

Objective: To determine analytically and through field tests the performance of various roof support systems when used in coal mine roofs where the major portion of the immediate roof is a thick layer of coal.

74. Evaluation of Ultrasonic Elongation Measurement Instrumentation

Objective: To evaluate a commercially available instrument to determine its suitability for underground use.

Mining and Minerals Processing Waste Stability

75. Evaluation of Filter Cloth for Stabilization of Coal Mine Wastes

Objective: To provide safer, longer lasting dams of coal mine waste materials through the use of filter media to control seepage. The immediate objective is to evaluate criteria for selection of filter cloth and test the filters under simulated mine waste dam environments. Also, to evaluate the deterioration of the cloths by sunlight and chemicals used in coal preparation plants and investigate possible unidirectional flow in some filter cloths.

76. Microseismic Monitoring of Waste Dam Stability

Objective: Using existing microseismic equipment and previously developed techniques, to install a system and monitor a waste embankment to demonstrate and define the limits and use of microseismic techniques for determining the stability of waste dams.

77. Effects of Horizontal Drains on Phreatic Surface and Factor of Safety

Objective: To model the effects of horizontal drains on the phreatic surface in mine waste embankments using an existing finite element code. For various embankment conditions, to determine optimum spacing and drain length to enhance stability and compare results with those at two existing embankments using horizontal drains.

78. Analytic Techniques--Waste Disposal

Objective: To conduct a field trial for determination of the factor of safety at a large waste embankment using a probabilistic slope stability analysis technique previously developed. To compare results using the probabilistic technique with those using traditional factor-of-safety analyses. Field and laboratory work will be undertaken to determine geotechnical properties of the embankment materials.

79. Electrokinetic Technique for Stabilizing Coal Sludge Ponds

Objective: To conduct a field test using electrokinetic techniques to dewater an abandoned coal waste sediment pond so as to allow effective reclamation or potential resource recovery in ponds containing fine coal with high heating values. This technique will be used to demonstrate the dewatering of 350 to 400 tons of coal sludge per day at a power cost of about \$2/ton.

80. Consolidation of Coal-Clay Wastes by Improved Flocculation Techniques

Objective: To demonstrate the technical feasibility of using an improved flocculation technique to dewater waste coal sludge generated in coal preparation plants to produce a consolidated, stable waste material that can be safely disposed of. A field test unit will be operated at a cooperating coal preparation plant at the rate of 300 to 500 gpm. The feasibility of mixing dewatered coal sludge with coarse coal refuse material for long-term stabilization of waste products will also be determined.

81. Compaction Criteria for Metal and Nonmetal Wastes

Objective: To determine the compaction characteristics of metal and nonmetal tailings. Optimum layer thickness, densities, and compactive effort will be developed on an operating waste embankment.

### Industrial Hazards

Program Objectives: To (1) determine how the quality of training can be increased to ensure miners can do their tasks safely and productively, (2) define the role of the human in all aspects of tasks required during the mining cycle, (3) determine how the human can be protected from the hazards of mining, (4) determine what information must be available to the miner and at what level to increase safety, and (5) determine what information must be available to reflect the human requirements in equipment designed for mining.

### Human Factors

1. Computerized Index of Available Training

Objective: To complete the development of a computerized index of training materials and aids available from

Government, academia, labor, management, and industry.

2. Development of Criteria for Evaluating New Hire and Annual Refresher Training

Objective: To continue to identify, field-test, and document performance criteria to be achieved via training mandated under 30 CFR, part 48.

3. Research To Reduce Back Injuries in the Mining Industry

Objective: To review existing training and education plans, determine the nature and type of back injuries common in underground mining; and develop a model program to reduce back injuries.

4. Human Factors Design of Mining Work Stations and Operator Compartments

Objective: To develop a computer model for researching the man-machine interaction in mining machines and development of procedures for work station design.

5. Workshop Series on Critical Human Resources in the Mining Industry

Objective: To bring together in a series of workshops the most active researchers involved in research about the human aspects of work in the coal industry that affect safety, absenteeism, and productivity.

6. Organizational Behavior Research

Objective: To research the relationship between organizational variables and mining accidents and injuries.

7. Feasibility Study on the Use of Visual Skills Training in Hazard Recognition for Underground Miners

Objective: To investigate the potential for training new miners to develop visual search and discrimination skills

for recognizing dangerous and safe roof and rib conditions.

8. Development of Performance Measures for Underground Equipment Operators

Objective: To assess the feasibility of developing a standarized method of performance evaluation for underground equipment operators.

9. Human Factors in Surface Mining Safety

Objective: To identify human factors relating to surface mine safety problems and provide background information to help correct these human-factors-related safety problems in the areas of safety motivation and training strategies.

10. Computer Based Training

Objective: To investigate the feasibility of conducting individualized, competency-based training utilizing commercially available microprocessors.

11. Fundamental Causes of Mine Accidents

Objective: To define the fundamental causes of mine accidents and determine corrective actions.

12. Advanced Advertising Techniques for Miner Safety Training

Objective: To utilize the most advanced advertising techniques available as a basis for a low-cost, in-mine, passive safety program to improve miner safety.

Electrical

13. Intrinsic Safety

Objective: To investigate problems related to a basic understanding of intrinsic safety, supply technical support to Bureau of Mines researchers, contractors, and MSHA, and participate in

national and international committees to develop recommendations and standards for using electrical equipment in potentially explosive atmospheres.

#### 14. Electrical Equipment, Devices, and Systems

Objective: To conduct preliminary investigations and final evaluations relative to contracted research and design tasks in the field of mine electrical systems and devices, and to pursue in-house basic research for the general improvement of metal and nonmetal mine electrical safety.

#### 15. Explosion-Proof Enclosures

Objective: To (1) determine minimum safe electrical clearances between uninsulated live conductors used in explosion-proof enclosures for voltages greater than 2,000 V and (2) investigate the mechanisms by which high-power arcs affect internal pressures in explosion-proof enclosures containing potting material.

#### 16. DC Power Systems

Objective: To demonstrate the effectiveness of the discriminating circuit breaker protection system by implementation of the system on a 1-mile test section in an active mine, evaluate sensitive ground fault interruptors and dead front panel construction techniques, and begin construction of a new cable reel tensioning device.

#### 17. Handbook for Improved Mine Equipment Battery Safety

Objective: To produce a practical handbook on battery safety for large surface mobile mining equipment. Emphasis will be placed on preventing electrical shock, fires, acid burns, and explosions. Guidelines for implementing a battery safety program at mine sites will be developed.

### Mine Equipment Safety

#### 18. Assessment of the Role of Mining Equipment Rebuild Shops in Bureau of Mines Technology Transfer Activities

Objective: To study, evaluate, and optimize the role of underground coal mining equipment rebuild shops in transferring the results of Bureau research into industry practice. The main objectives of the continued effort will be to expand a directory of rebuild shops and to work more closely with cooperating rebuild shops to incorporate Bureau-developed research into their operations.

#### 19. Participation in the Institute of Shaft Drilling Technology (ISDT)

Objective: To coordinate Bureau research results and participate with industry in the advancement of safer shaft sinking practices.

#### 20. Extended Field Validation for the Front-End Loader Stability Indicator

Objective: To validate the utility of the front-end loader stability indicator with extended field operation and to increase manufacturer interest in the system for commercial production.

#### 21. Development of Technology To Reduce Equipment-Related Accidents

Objective: To provide the mining industry with solutions to selected equipment safety problems and to provide advanced technology to minimize human exposure to mining hazards. This will be accomplished by development of devices to sense the presence of workers near dangerous equipment situations, identification and investigation of special cab and canopy problems, validation of automatic steering technology for selected mining equipment, and development of apparatus to minimize human labor for selected dangerous mining situations.

22. Assessment of Canopy Performance in the Underground Mining Industry

Objective: To determine and validate if limited coverage protective structures can be successfully employed in low-seam mining conditions and not adversely affect operator visibility and comfort. To assess the need for operator side protection on underground mining equipment.

23. Mobile Equipment Maintenance Safety

Objective: To determine and quantify hazards and causes of maintenance- and repair-related accidents on large surface mining equipment. To prepare a report on recommendations for new maintenance methods, maintenance equipment, or modified designs to improve safety during machine maintenance.

24. Underground Equipment Brake Performance Evaluation

Objective: To determine braking dynamics of underground mining and to classify them according to machine type.

25. Operator Protection for Surface Mining Equipment

Objective: To validate the Bureau-developed safety vest restraint system and the improved seat design to provide equipment operators with comfort and restraint in the event of rollover or collision.

26. Surface Mine Equipment Safety

Objective: To improve surface mine mobile equipment safety. The effectiveness of Bureau-developed driver alertness monitors and improved ladder systems will be evaluated.

27. Robotics Research Program

Objective: To investigate the applicability of robotics for solving safety problems related to mining and to keep abreast of current robotics technology.

28. Collision Protection Systems

Objective: To develop and validate techniques that reduce the vehicle collision hazard in surface mines.

Illumination

29. Illumination Research

Objective: To determine the potential benefits of the proposed MSHA surface mine illumination standards, develop low-glare lighting sources and systems for use in underground coal mines (particularly for thin-seam applications), develop a reflectance determination procedure for underground metal and nonmetal mines, and develop technology needed to enable the underground metal and non-metal industry to provide adequate and effective illumination systems for its workforce.

Mine Communications and Monitoring

30. Performance Standards and Systems Approach to Mine Monitoring

Objective: To conduct investigations and analyses, collect data, evaluate hardware, and maintain a base of knowledge in support of continuous, remote mine monitoring. Specific areas of concern include reliability performance, system safety, cost and benefits, data security, performance specifications, and the impact of regulations on monitoring systems.

31. Multirange Prototype Methane Monitor Study

Objective: To develop a multirange 0% to 5%, 0% to 100% methane fixed-point transducer prototype.

32. Mine Telemetry and Environmental Surveillance Systems

Objective: To perform an extensive in-mine evaluation and data gathering of current mine monitoring validation projects and to investigate color graphic

display for rapid visual display of alarms indicating mine emergencies.

### 33. Underground Communications Systems

Objective: To develop and field-validate a variety of special techniques, systems, and hardware for the purpose of improving underground mine communications.

### Haulage and Materials Handling

#### 34. Wire Rope and Hoisting Research Program

Objective: To operate the Wire Rope Laboratory to collect the data necessary to evaluate nondestructive testing devices and develop criteria for identifying and accurately measuring the degradation of wire rope.

#### 35. Materials Handling Equipment Development

Objective: To investigate methods by which various facets of mine materials handling and haulage activities can be made less labor intensive, thus reducing the probability of accidents.

#### 36. Evaluation of Nondestructive Testing Equipment and Methods Using a Laboratory Standard

Objective: To develop a laboratory standard rope incorporating a range of anomalies that can occur and begin evaluation of nondestructive testing devices.

#### 37. Corrosion Rating Standard For Wire Rope

Objective: To research and develop a corrosion standard for wire rope to be used by the mining industry to evaluate and designate the degree of corrosion degradation in a consistent manner.

#### 38. Electromagnetic Nondestructive Testing of Wire Rope

Objective: To formulate a program plan for the research and development of

an effective electromagnetic nondestructive testing method for wire ropes.

#### 39. Effect of Unsafe Parameters on Wire Rope Life Using the University of Illinois Computer Model

Objective: To develop a better understanding of wire rope behavior by performing a computer analysis using varying rope parameters and defining the parameters necessary for further destructive testing.

#### 40. Self-Centering Coupler for Track Haulage Vehicles

Objective: To lessen the possibility of injury during coupling and uncoupling operations by designing, fabricating, and testing a coupler centering device capable of centering most coupler-truck combinations, thereby eliminating the need for manual coupler alignment.

#### 41. Conveyor Safety

Objective: To develop improved shutoff and lockout hardware, and investigate alternatives to unsafe conveyor-related work practices, such as conveyor man-trip usage and startup warning procedures to reduce the number of conveyor-related accidents.

#### 42. Laboratory Analysis of Wire Rope

Objective: To define the mechanical and chemical characteristics of wire rope that affect its degradation in mine hoisting and determine mechanisms of hoist rope deterioration through laboratory analysis of new and used wire ropes. To relate the results to manufacturing procedures, rope construction, or in-use procedures in order to improve the performance and safety of wire rope used in mining.

#### 43. Wire Rope Cleaning and Lubrication

Objective: To categorize cleaning and lubrication techniques into groups such as specific applications, effectiveness, cost, and commercial availability,

and to develop a plan for evaluating rope lubricants and lubricating techniques.

#### Postdisaster

Program Objectives: To develop technology that will (1) enable survivors of a mine disaster to escape from the mine or to survive while awaiting rescue by providing protection against toxic and/or oxygen-deficient atmospheres, (2) aid in the location of miners trapped underground, using seismic and electromagnetic means of communication, and (3) facilitate postdisaster rescue and recovery operations through surface monitoring of conditions underground, emergency communications, and mechanized transport and lifesupport equipment for mine reentry and rescue operations.

#### Survival

##### 1. Development of Life Support Technology

Objective: To develop technology that maximizes the likelihood that a miner will survive a mine disaster and to improve the safety and efficiency of mine rescue and recovery missions.

##### 2. Long-Term Field Evaluation of Self-Contained Self-Rescuers

Objective: To determine if the testing procedures recommended by the manufacturers for self-contained self-rescuers (SCSR's) are adequate and to study the effects of long-term mine storage on SCSR performance.

#### Communications

##### 3. Trapped Miner Location and Communication

Objective: To develop emergency detection and location systems for postdisaster rescue efforts, evaluate hardware for these rescue efforts, and provide technical assistance to contractors conducting field test programs.

#### Rescue and Mine Recovery

##### 4. A Medium-Frequency System for In-Mine Location, Communication, and Rescue

Objective: To develop a MF communication system that will work in conjunction with breathing apparatus used by mine rescue teams.

#### Explosives

Program Objectives: To assess the problems associated with the safe and effective use of explosives in all types of mining activity including fixed explosives, blasting agents, blasting devices, and blasting accessories. To conduct fundamental studies of explosive behavior and apply the results in the development of new technology. To develop new and improved test procedures as new mining methods are introduced and new types of explosives are formulated.

##### 1. Review of Blasting Practices in Gassy Noncoal Mines

Objective: To recommend safe blasting practices for gassy noncoal mines and recommend research needed to develop improved blasting practices for these mines. To examine current and proposed blasting practices in gassy noncoal mines to identify hazardous practices.

##### 2. Development of Improved Blasting Procedures

Objective: To develop improved safer blasting procedures for use in metal and nonmetal mines. To make recommendations during FY 83 for preventing misfire accidents through examination of the causes of misfires, methods of detection, and techniques for disposing of misfires.

##### 3. Determination of Recommended Blasting Products and Procedures in Gassy Noncoal Mines

Objective: To generate experimental information as a basis for developing

guidelines and standards for nonincendive explosives and blasting agents and permissible blasting practices in oil, oil shale, and other noncoal mines having potential gas or dust explosion hazard.

4. Investigation of Explosives Products Involved in Coal and Noncoal Mine Accidents

Objective: To provide supporting research for accident investigations and on potentially hazardous situations, products, or practices identified by MSHA and so to establish guidelines for the development, clarification, revision, or enforcement of related safety standards.

5. Analysis of Mine Blasting Accidents

Objective: To insure that the Bureau research effort is directed toward the real causes of blasting accidents by analyzing coal mine blasting accidents. This effort will include analysis of metal and nonmetal mine accidents.

6. Improvements of Nonincendive Explosive Charge for Unconfined Shooting

Objective: To develop and test versions of the nonincendive explosive charge for applications where the current prototype would not be suitable. For applications such as breaking larger or smaller stone slabs, or dislodging hung-up roof rock, it would be advantageous to develop larger and smaller charges and thin charges that will fit into crevices in the stone.

7. Fire Hazard Evaluation of Explosives and Blasting Agents

Objective: To (1) perform large-scale fire tests on materials normally classified as blasting agents to verify previous work on the development of fire hazard estimation procedures, (2) develop information in the area of sensitivity to direct electrical stimuli, (3) perform routine thermal tests in connection with accident investigations and new blasting materials, (4) perform thermal tests

on nonelectric initiating systems, and (5) further develop the thermal explosion tests, for large-size samples, to determine at which temperature decomposition or explosion occurs.

8. Generation of Hazard Criteria and Test Procedures for Explosive Products

Objective: To (1) perform an evaluation and comparison of the characteristics of all types of nonelectric initiating systems, (2) evaluate new explosives and blasting accessories, (3) investigate merits of (a) vented versus unvented "drop trailers" used as storage facilities for blasting materials and (b) grounded versus nongrounded explosive storage magazines, and (4) develop improved capability for testing and assessing the sensitivity of blasting materials.

9. Basic Research on Initiation and Propagation of Detonation

Objective: To formulate explosive criteria that reflect the interrelationship of explosive characteristics, explosive states, stimulation mechanisms, and reaction modes. This work would involve research experiments with different relationships between pulse characteristics (form, strength, duration, impulse, etc.) and theoretical model development intended to correlate explosive properties with the salient pulse characteristics.

10. Investigation of Pressure Desensitization of Permissible Explosives

Objective: To update current and develop new schedules and standards as needs arise for permissible explosives and related articles, stemming devices, and blasting devices. To recommend changes to MSHA for the purpose of providing safer and more effective explosives and devices. To extend basic knowledge by investigating mechanisms involved in and associated with pressure desensitization and performance of explosion.

11. Evaluation of New Permissible Explosives and Develop Improved Permissible Coal Mine Explosives

Objective: To continue evaluating explosives and explosive devices for underground coal mine use. To monitor field samples for conformance with their basic specifications. To research those items that will improve the safety and performance of coal mine explosives, including the relatively new water gel and water emulsion permissibles.

Systems Engineering

Program Objectives: To develop methods for evaluating the impact of specific technological improvements or inadequacies on the total mining operations and identify problems whose solutions would provide the greatest health and safety benefit. To operate and maintain underground research and test facilities for use in testing and demonstrating new procedures and equipment before they are tested in commercial mines.

Systems Analysis

1. Risk Analysis of Job Tasks and Other Mining Activities

Objective: To determine for current high-risk tasks and other mining activities if risk is decreasing or increasing with time. To continue studying risk and supplementary techniques that aid planning research programs using HSAC data.

2. Health and Safety Considerations of Novel Mining Systems

Objective: To review and assess the state-of-the-technology of selected novel mining systems beginning to emerge.

3. Information Retrieval System for Costs of Mine Accidents and Applications

Objective: To provide information to the mining industry and researchers for making decisions. To (1) convert the 1981 and 1982 HSAC accident statistics

into cost statistics, (2) identify existing (statistical or other) types of methodologies appropriate for analyzing these data, (3) simplify run procedures on (1) so that any interested person may conduct the on-line retrieval and analysis, (4) conduct correlation statistics among various accident statistics and mine characteristics, (5) identify useful information that can be obtained from the data and methodologies, and (6) apply the technique to real situations and extract information from the mine accident data bases by applying the latest statistical techniques designed for categorical data (a characteristic of some of the mine accident data).

4. Cost Effectiveness of Bureau-Developed Methane Drainage Techniques and Other Technology

Objective: To study the cost and benefits of the different methane drainage techniques and to forecast trends in mining systems impacting on or being impacted by methane control.

5. Demonstration of Sheathed Explosive Charge Blasting Practices

Objective: To develop instrumentation to evaluate and demonstrate the sheathed explosive charge.

6. Hazard Analysis of Underground Mining

Objective: To (1) develop recommendations for new technology or modifications of current practices to reduce the roof fall hazard to personnel making methane measurements at the coal face, (2) identify and analyze major safety problem areas in gassy noncoal mines, and (3) quantify operational parameters in surface and underground mines and specify component performance requirements to assure reliable operation of safety systems on mobile equipment.

7. Application of Mine Safety Hardware

Objective: Perform a benefit-cost analysis of the Bureau-developed fueling

area fire protection system for underground noncoal mines.

### Test Facilities

#### 8. Operation of Lake Lynn Laboratory

Objective: To operate the Lake Lynn Laboratory in support of ongoing Bureau of Mines programs. Examples of programs to be pursued include testing new types of explosion barriers or ignition-suppression devices, diagnosis and abatement of methane roof layers, minimum initiation conditions for dust explosion, and explosion and hydrostatic testing of candidate explosion-proof bulkheads and water seals.

#### 9. Operation of Underground Test Facilities

Objective: To operate the two experimental mine facilities located at

Bruceton for the purpose of supporting ongoing research and development projects. Examples of project activities scheduled for work in the mine facilities include construction and testing of explosion-proof bulkheads, trickle duster testing in return air courses, coal and oil shale fire tests, reduction of respirable dust generation by coal cutting equipment, and ground control instrumentation tests.

#### 10. Operation of Twilight Mine Radiation Facility

Objective: To continue to operate and maintain an underground uranium mine as a test facility to provide typical mine environmental conditions for research and development studies conducted by the Bureau of Mines, MSHA and other Government agencies, and outside contractors in the area of radiation hazards.

## PART II.--CONTRACT RESEARCH

### Health

#### Respirable Dust

Program Objectives: To develop procedures for controlling the respirable dusts that still constitute the severest health problem facing the mining and minerals processing industries. To develop and/or improve techniques and equipment to measure and prevent formation of hazardous dust concentrations and to protect miners against dusty atmospheres.

#### Control of Generated Dust

##### 1. Conveyor Belt Dust Control

Objective: To reduce the occurrence of respirable dust at conveyor belt loading, dumping, screening, and transfer points by cost-effective dust control systems. The effort shall consist of data collection and analysis, design and fabrication of a dust control system, and in-plant evaluation. This is a continuation of an ongoing effort.

##### 2. Mine Evaluations of Longwall Dust Control Techniques

Objective: To evaluate the effectiveness of available dust control technology for double-drum shearer longwall sections in a coordinated, systematic program at several longwall test sections, and to make the results available to the entire coal mining industry. These evaluations should guide the coal mining industry toward the best available technology to control respirable dust with the least adverse impact on coal production. This is a continuation of an ongoing effort.

##### 3. Improved Canopy Air Curtain

Objective: To develop an improved canopy air curtain system for mining and mineral processing use and to investigate the feasibility and develop a method and hardware that will remove gaseous contaminants in addition to particulates from

the mine air that will be delivered by the canopy air curtain. This is a continuation of an ongoing effort.

#### 4. Near-Face Infusion for Longwall Dust Control

Objective: To evaluate the feasibility and effectiveness of utilizing near-face water infusion as a dust control technique on longwall mining operations. As much work has been done by foreign countries to develop equipment for this procedure, the main effort will be to make the modifications necessary to adopt this equipment to U.S. mining conditions, and then to conduct underground tests at various areas along the longwall face. This is a new RFP.

#### 5. Ventilation and Dust Control of Low Auger Mining Sections

Objective: To provide a ventilation system with sufficient capability to significantly reduce the dust exposure at the jacksetter location. To design and install a water spray system that would suppress dust and move the air towards the desired direction. In-depth full-scale model testing of a coal mine working face area with an auger-type mining machine, water spray system(s), and ventilation with line curtains or tube will be required to define the optimum system prior to underground evaluation. This is a new RFP.

#### 6. Evaluation of Electret Fiber Material for Mining and Milling Applications

Objective: To investigate the feasibility and practicality of using electret fiber material as a collection medium to remove respirable dust and other contaminants from the air in mining and mineral processing operations. This is a new RFP.

#### Dust Instrumentation and Measurement

##### 7. Guidelines for Selecting Sampling Location(s) on Longwall Shearer Faces

Objective: To provide guidelines for selecting dust sampling locations on longwall mining faces. Sampling will be conducted on three or more longwall mining sections using shearers. Multiple instantaneous sampling instruments will be used to measure simultaneously dust levels at locations up to 200 ft downwind of the shearer. Airflow characteristics will be monitored, and any physical obstructions that might affect the airborne distribution of dust will be noted. Information will be used to produce a dust concentration map to aid in selection of a sampling location. This is a new RFP.

#### Noise Control

Program Objectives: To identify noise sources in underground and surface mines and in related mineral processing surface facilities, to abate these noise sources through both field retrofit and factory redesign approaches so that the mining operations and minerals processing activities meet the Federal noise exposure standards, to provide more accurate measurement of the noise environment, and to provide industry with the technical knowledge necessary to select, design, and implement noise control measures.

##### 1. Noise Study of Longwall Mining Systems

Objective: To develop quieter longwall mining equipment. The noise problems of longwall systems shall be identified, and feasible engineering controls that achieve quieter operation without affecting production shall be assessed and demonstrated. It is anticipated that the demonstration phase will involve a

cooperative effort with a longwall equipment manufacturer. Prototype development of a quieter shearer was initiated in FY 82. This is a continuation of an ongoing effort.

## 2. Current Levels of Whole-Body Vibrations in Mines

Objective: To determine and assess the present levels of mine personnel exposure to whole-body vibrations and to compare these levels with the results of a medical literature search relating vibration parameters to physiological effects. To assess the capability of commercially available high-performance seats to reduce the adverse effects of whole-body vibration on the health, safety, and productivity of the machine operator.

## 3. Retrofit of Underground Load-Haul-Dump Machines With Noise Control Packages

Objective: To develop retrofit noise control technology for specific models of load-haul-dump (LHD) machines. Noise control techniques shall be implemented and in-mine tested. Participation of the contractor with equipment manufacturers and mine operators is considered essential in conducting this contract, which is a continuation of ongoing efforts to quiet LHD's through retrofit means.

## 4. Development of a Prototype Hand-Held Rock Drill for Use in Metal and Nonmetal Mines

Objective: To develop a reduced-noise hard rock drill for use in the metal and nonmetal mining industry. The basic technology that was successful in the development of a quieter coal mine pneumatic stoper drill shall be applied. This is a continuation of an ongoing effort.

## 5. Integrated Approach to Noise Control for a Continuous Miner

Objective: To develop and field-test a noise-controlled continuous miner. The

intent of this project is to take an integrated approach to noise controlling a continuous miner. Noise control technology that will be developed for the cutting head will be incorporated with previously developed chain conveyor controls and other noise controls into a test bed piece of equipment. The technology will be validated by underground testing. This is a continuation of an ongoing effort.

## 6. Development of Prototype Production Noise-Controlled Jumbo Drills

Objective: To develop a cost-effective, manufacturable, quiet jumbo-mounted drill through redesign of major components. A preproduction prototype jumbo drill is to be designed, fabricated, and field-tested. This is a continuation of an ongoing effort.

## 7. Assessment of Noise in the Metal and Nonmetal Mining Industry

Objective: To gather data on noise levels, machine populations, duty cycles, and operator populations in the metal and nonmetal mining industry and to use these data to quantify the noise exposure impact in this industry and to identify primary noise sources and potential impact of noise control research. This is a continuation of an ongoing effort.

## 8. Development of Engineering Design Concepts for Percussion Drill Steel Noise

Objective: To develop and demonstrate the feasibility of novel engineering approaches to controlling the noise of drill steels. This is a new RFP.

## Industrial Hygiene (Toxic Substances)

Program Objectives: To identify and control health hazards in surface and underground mines and mineral processing plants caused by toxic and/or noxious gases and fumes, and certain particulates produced by explosives, combustible materials, and diesel engines. To develop and evaluate new instrumentation,

methods, and procedures for monitoring these substances. To analyze alternative power sources that may have health advantages over existing mine diesels.

#### Toxic Gases and Materials

##### 1. Toxic Fumes From Explosives Tests in Underground Mines

Objective: To determine the presence of trace toxic products such as nitrosamines and others that may be present along with the expected products CO, CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, and NH<sub>3</sub> in the fumes from explosives fired at the working face in a mine. Results will be used to characterize the transient nature of fumes generated during blasting, and to compare these in-mine results with results obtained by laboratory test methods. This is a continuation of an ongoing effort.

##### 2. Monitoring of Mine Air Pollutants

Objective: To develop and test engineering approaches for the control of mine air quality. To characterize exhaust gas distributions in various ventilation configurations in deadend drifts. To evaluate exhaust control hardware in simulated and real conditions. To investigate methods to identify diesel soot on respirable dust filters. This is a continuation of an ongoing effort.

#### Diesels

##### 3. Control of Diesel Exhaust in Mines--Aftertreatments

Objective: To develop and field-test an exhaust emission control system for diesel-engine-powered equipment suitable for underground mining applications. Combinations of emission control methods including exhaust gas recirculation, catalytic converters, particulate filters, and water-fuel emulsification will be investigated to determine the optimum combination for mining vehicles. The final combination will be field-tested.

This is a continuation of an ongoing effort.

##### 4. Control of Diesel Exhaust in Mines--Fuel Modifications

Objective: To investigate the control of diesel exhaust emissions by fuel modifications that can be made at the mine site. Specifically, water-fuel emulsifications will be evaluated, and optimization of the engine operating parameters to combust these fuels will be performed. This is a continuation of an ongoing effort.

##### 5. Development of a Clean Internal Combustion Engine for Underground Mining Machinery

Objective: To evaluate a diesel-metal hydride power source (a diesel engine modified to burn hydrogen) for use in underground mining equipment from the standpoint of mine safety, technical feasibility, industry acceptance, and economics. Hydrogen fuel will be stored in a metal-hydride lattice. To design a program leading to construction of a prototype and subsequent demonstration of such a vehicle should it be warranted. This is a continuation of an ongoing effort.

#### Ventilation

Program Objective: To develop ventilation systems required to maintain a safe and healthful atmosphere conducive to efficient work output in noncoal mines.

##### 1. Optimization and Testing of Water-Spray Coolers

Objective: To optimize the presently available 5,000-cfm water-spray cooler to assess its potential for larger cooling capacity operation. To investigate new and improved direct-contact, air-water heat exchangers for cooling the hot working areas of deep mines. This is a continuation of an ongoing effort.

## 2. Water Turbine Energy Recovery System

Objective: To design, develop, and test a fluid motor system that takes energy from the high-pressure water flowing in vertical pipelines in deep hot mines and converts this energy into useful mechanical or electrical energy. This is a continuation of an ongoing effort.

### Safety

#### Methane Control

Program Objectives: To develop, demonstrate, and transfer technology that will prevent the formation of flammable methane-air mixtures in underground mine workings through improved ventilation and procedures for degasifying the coal seam in advance of and during mining. To establish correlations between the geology of the material to be mined and its gas content, and to use these to predict methane emission hazards.

#### Control During Mining

##### 1. Improved Diffuser and Spray Fan System for Ventilation of Coal Mine Working Faces

Objective: To provide a spray fan system with sufficient methane control capability for any gassy work face; to devise, develop, and test a new auxiliary face ventilation concept, combining the advantages of diffuser fan and water spray ventilation; to evaluate, modify, and upgrade sensor positioning and protection for machine-mounted methane monitors. This is a continuation of an ongoing effort.

#### Ground Control

Program Objectives: To conceive, develop, demonstrate, and transfer technology that will prevent mine accidents attributable to falls of ground, outbursts, slope failures, and collapse of waste impoundment structures.

## Roof Support Systems

##### 1. Design, Fabricate and Test a Pumpable Bolt System

Objective: To develop a system for installing longer-than-seam-height fiberglass core, epoxy-grouted roof bolts. This is a continuation of an ongoing effort.

##### Safe Support Installation

##### 2. Remote Manually Controlled Roof Bolter

Objective: To develop a roof bolter in which the operator performs the bolting function from a protected location under permanently supported roof through the use of remote controls. This is a continuation of an ongoing effort.

##### 3. Confined Space, Drag-Jet Drill

Objective: To develop a longer-than-seam-height roof bolt hole drill that includes the best characteristics of a water jet drill. This is a new RFP.

##### 4. An Electrically Powered Scaling Bar

Objective: To develop a hand-held portable scaling bar that uses electro-hydraulic energy. This is a new procurement effort as the result of an unsolicited proposal.

##### 5. Development of a Roof Competence Tester

Objective: To develop and evaluate a hand-held instrument for accuracy and reliability in detecting cracks, fissures, delaminations, and poorly cemented and otherwise weak rock structure in coal mine roofs. The instrument shall be suitable for use with all thicknesses of coalbeds and different roof compositions. This is a continuation of an ongoing effort.

## 6. Retreat Mining Support System

Objective: To design, build, and field-demonstrate a second-generation mobile roof support machine for retreat mining that will operate in 5- to 15-ft coal seams. This is a continuation of an ongoing effort.

## 7. Inorganic Grout Slurry Bolters

Objective: To design, build, and mine test a machine that will mix and inject fast-setting inorganic grouts. The final object of the program is commercial acceptance of the bolter. Phase III (laboratory testing of the complete synthesized system) and phase IV (mine testing and final report) shall be completed. This will include installation of 70 to 100 bolts to support an intersection. This is a continuation of an ongoing effort.

## 8. Develop Equipment To Expedite the Safe Installation of Roof Trusses

Objective: To design and demonstrate mechanical installation equipment and practices for solid-rock roof trusses which will speed up the cycle time yet reduce the handling hazards associated with current practices. This is a continuation of an ongoing effort.

## 9. Fabricate and Test an Articulated Remote, Manual Roof Bolter

Objective: To fabricate, laboratory-test, and perform an underground demonstration of a prototype, articulated, remote manual roof bolter to evaluate the amount of accident reduction potential and production rate improvement. This is a continuation of an ongoing effort.

## 10. Extended Field Test of Torque-Thrust Control and Hardened Washers

Objective: To determine the effects of using hardened washers and a

Bureau-developed, torque-thrust control bolter on uniformity of bolt tension and roof control. This is a continuation of an ongoing effort.

## 11. Resin Injection and Resin Doweling for Longwall Face Stabilization

Objective: To define and rank problems of roof and face stabilization in longwalls, evaluate foreign and domestic technology in resin-injection and resin-doweling for application in U.S. mines, select those techniques that indicate the greatest benefits per cost and are not unnecessarily hazardous, develop testing procedures to demonstrate their effectiveness on longwall stabilization problems, perform and document the demonstration, and reassess the cost and safety benefits. This is a continuation of an ongoing effort.

## 12. Remote Drill-Bolting System for Metal and Nonmetal Mining

Objective: To design, build, and mine-test a remote drill-bolt system for metal and nonmetal mining that will remove the bolter operator from the bolting operation and place him or her in a protected area not exposed to unsupported ground or moving equipment. This is a continuation of an ongoing effort.

## Industrial Hazards

Program Objectives: To (1) determine how the quality of training can be increased to insure miners can do their tasks safely and productively, (2) define the role of the human in all aspects of tasks required during the mining cycle, (3) determine how the human can be protected from the hazards of mining, (4) determine what information must be available to the miner and at what level to increase safety, and (5) determine what information must be available to reflect the human requirements in equipment designed for mining.

## Human Factors

### 1. Determining the Effect of Incentive Programs on the Occurrence of Accidents, Injuries, Productivity, and Employee Attitudes

Objective: To identify types of incentive programs that reduce accidents and injuries and are acceptable to the management and employees of underground coal mining companies. This is a new RFP.

### 2. Formalizing Occupational Training

Objective: To continue development of instructional guides and performance criteria for selected underground and surface mining tasks. This is a continuation of an ongoing effort.

### 3. Preparation of Baseline Training Materials for Assisting Compliance and Accident Reduction in the Metal and Nonmetal Mining Industry

Objective: To establish health and safety performance criteria and evaluation techniques for the underground salt mining industry. This is a continuation of an ongoing effort.

### 4. Increasing the Effectiveness of Mine Management by Career Development and Job Engineering

Objective: To increase the safety and productivity performance of mine managers and supervisory personnel by researching ways to apply recently developed approaches to human resource utilization and integrating new methods of supervisory and managerial training with on-the-job career development techniques. This is a new RFP.

## Electrical

### 5. Ground and Ground Bed Monitoring

Objective: To determine methods of reducing ground bed conductor corrosion, including the bias current method. To improve measurement methods, particularly

where large ground beds or extremely high or low resistivities are involved. To investigate innovative approaches to ground monitoring for feasibility of extending coverage to all varieties of grounding systems. This is a new contract.

### 6. Implementation of Shock Prevention in Mine Equipment and Machinery

Objective: To verify that the shock prevention concepts now being completed will be practical and effective. To conduct final evaluation of these concepts and initiate in-mine tests of concepts showing the most promise at a power center and one piece of face equipment. This is a new contract.

### 7. Administration and Maintenance of the Mine Electrical Research Laboratory

Objective: To maintain support of the mine electrical research laboratory for use on Bureau of Mines in-house and contract research projects. This is a continuing contract.

### 8. Mine Power System Monitoring

Objective: To formulate an overall basis for monitoring mine power systems. The performance of hazard-prediction techniques shall be evaluated by mathematically modeling electrical machines and cable-connected electrical machines under various deteriorating conditions. To verify results of algorithm computations to predict a given incipient safety hazard, and perform a system error analysis. A microprocessor prototype shall then be constructed and in-mine-tested. This is a new contract.

### 9. Mine Hoist Electrical System Study

Objective: To develop a maintenance and inspection manual for hoisting systems used in U.S. mines. The maintenance section will aid operators in performing periodic preventive maintenance on hoists, while the inspection portion will aid MSHA in performing hoist inspections. This is a continuing contract.

Mine Equipment Safety10. Advancement of Cab and Canopy Design and Use in Coal Mines

Objective: To update the cab and canopy catalog and print additional copies. This will conclude the effort.

11. Extension of Low-Coal Cab and Canopy Technology To Include Coal Drilling and Cutting Machines

Objective: To develop adequate human-engineered operator cabs with protective canopies for coal drilling and cutting machines, and validate these in low-coal. This is a continuation of an ongoing effort.

12. Validation of Remote Operator's Compartment for Controlling a Low-Seam Continuous Miner

Objective: To develop and validate the technology for controlling a low-coal continuous miner from a remote operator station. This is a continuation of an ongoing effort.

13. Portable Dynamic Brake Testing Apparatus

Objective: To develop a testing apparatus to enable remote evaluation of brake performance on underground mining vehicles at near-zero speeds and higher. This will conclude the project.

14. Extended Validation of Low-Coal Bridge Carrier Operator's Compartment with Canopy

Objective: To further validate the utility of a successful operator compartment with canopy in lower coal seams. This will conclude the project.

15. Development of ROPS Performance Criteria for Large Mobile Mining Equipment

Objective: To provide data on large machine ROPS performance criteria by

tests and computer analysis to determine if present criteria are adequate. This will conclude the project.

16. Analysis of ROPS in Service For at Least 5 Years

Objective: To examine and evaluate the fatigue-related problems of ROPS owing to vibrations inherent to the machines on which they are mounted and the terrain characteristics of the surface mine. This is the continuation of an ongoing effort.

Illumination17. Feasibility Study of Alternate Methods for Mine Illumination Systems

Objective: To evaluate methods of mine illumination where minimal luminance requirements are met without causing glare problems and to investigate alternate methods of specifying illumination regulations to provide maximum luminance with minimum glare. This is a continuing contract.

18. Development of Minimal Luminance Systems for Underground Metal and Nonmetal Mines

Objective: To design illumination systems for selected work areas and tasks as recommended by present studies. These designs will be evaluated to verify that these systems can meet the minimal requirements without producing excessive glare. This is a new contract.

Mine Communications and Monitoring19. Multiplex Distribution System for Multichannel Pager Phone Communication

Objective: To design, fabricate, and validate a multichannel telephone communication system using the selectable pager phone as a local intercom which will provide maximum communication capability at minimum cost. This is a continuation of an ongoing effort.

20. Guidelines for Control Systems in Mines

Objective: To investigate guidelines for safe implementation of processor-based, remote control systems in underground mines. A general philosophy on safety considerations for control systems will be arrived at which can be applied to hoists, fire suppression systems, belts, rail haulage, face equipment, fans, circuit breakers, and other equipment. This is a new RFP.

21. An Analysis of the Interaction of Mine Radio Systems With Mine Telemetry and Control Systems

Objective: To investigate potential problems concerning the parasitic coupling of electromagnetic energy into environmental or control telemetry lines, and to environmental sensors or control devices. This is a new RFP.

22. Second Western Mining Industry Electrotechnology Conference

Objective: To provide a forum for industry and Government to present the latest developments in mine health and safety related electrotechnology. This is a directed RFP.

23. Evaluate Hardware for Medium-Frequency Mine Wireless Communication System--Phase IV

Objective: To evaluate and validate Bureau-developed medium-frequency hardware under mine operational conditions and to document the results. This is a continuing contract.

Haulage and Materials Handling

24. Safety Evaluation of Conveyor Belt Cleaning Systems

Objective: To determine conveyor belt cleaning system parameters to reduce the amount of hazardous hand labor associated with the cleanup of conveyor areas

that is required owing to the use of ineffective belt cleaners. This is a continuation of an ongoing effort.

25. Development of Consistent Low-G Hoist Arrestment Devices

Objective: To complete the development of predictable consistent low-G arrestment devices that eliminate the high transient forces during an arrestment. This is a continuation of an ongoing effort.

26. Hoisting System Components--Selection and Guidelines

Objective: To develop a comprehensive set of guidelines that cover all aspects of analysis, selection, and design of the electrical and structural components of a hoisting system. This is a continuation of an ongoing effort.

Postdisaster

Program Objectives: To develop technology that will (1) enable survivors of a mine disaster to escape from the mine or to continue to survive while awaiting rescue by providing protection against toxic and/or oxygen-deficient atmospheres, (2) aid in the location of miners trapped underground, using seismic and electromagnetic means of communication, and (3) facilitate postdisaster rescue and recovery operations through surface monitoring of conditions underground, emergency communications, and mechanized transport and life support equipment for mine reentry and rescue operations.

Survival

1. Guidelines for Oxygen Self-Rescuers

Objective: To develop recommendations on the safest, most practical methods for complying with new regulations requiring that all underground coal miners be provided a self-contained self-rescuer (SCSR). This is a continuation of an ongoing effort.

## 2. Physiological Responses of Coal Miners to Emergency

Objective: To quantitatively evaluate the physiological responses (circulatory and respiratory) of male and female miners while wearing self-contained breathing apparatus (SCBA) for purposes of emergency escape or rescue. This involves measuring the psychomotor and physiological costs to the wearer while breathing against (1) positive pressure, (2) high CO<sub>2</sub> concentrations, and (3) variable resistance. Within the next 2 years, this contract should define safe limits for the parameters listed and publish data to support said limits to support efforts to revise MSHA-National Institute for Occupational Safety and Health (NIOSH) regulations (30 CFR 11). This is a continuation of an ongoing effort.

## 3. Computerized Breathing Metabolic Simulator

Objective: To purchase a computerized breathing and metabolic simulator for use in conducting in-house research related to breathing apparatus. This is a new RFP.

### Communications

## 4. Electromagnetic Rescue System for Deep Mines

Objective: Over the past several years, the Bureau has been experimenting with voice frequency (VF) communication systems for detection and location of workers trapped underground. The present

system has been shown to be effective in a substantial number of coal mines no deeper than 300 meters. However, for deeper mines, which comprise about 10 pct in number and involve 20 pct of the work force, improvements will be necessary. The overall goal of this effort is to investigate possible alternatives, select the most promising of these options, and build and demonstrate implementing hardware. This is a continuation of an ongoing effort.

## 5. Adaptive Noise Cancellation Techniques

Objective: To study adaptive noise cancellation techniques using multiple three-axis loop antenna and to develop algorithms to implement these techniques. This is a continuation of an ongoing effort.

### Rescue and Mine Recovery

## 6. Trapped Miner Location Systems Performance Guidelines

Objective: To establish performance guidelines for systems developed for locating trapped miners. This is a new RFP.

## 7. Rescue Team Helmet

Objective: To build five preproduction rescue team helmets (RTH), to be compatible with the new low-profile, lightweight rescue breathing apparatus (LPRBA). This is a continuation of an ongoing effort.



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